It was traders who tilted the scale in favour of the new number system in the Arab world.

In AD 773, at the height of Arab splendour, there appeared at the court of the Caliph, Al-Mansur, in Baghdad a man from distant India. This traveller had brought with him several volumes of writings from India. Al-Mansur promptly got them translated into Arabic and later several Arabic scholars assimilated their contents. One among them was Abu Jafar Mohammed ibn Musa Al-Khowarizmi (which, freely translated, means ‘Mohammed, the father of Jafar and the son of Musa, the Khowarizmian’, the last word originating from the Persian province of Khoresem). This man, who lived between AD 780 and 850, was one of the greatest mathematicians of the Arab world and he quickly realised the importance of the number system used in the Indian writings. In fact, he wrote a small book explaining the use of these numerals around AD 820.

The original of this book is lost but there is evidence to suggest that it reached Spain in about AD 1100; there it was translated into Latin by an Englishman, Robert of Chester. And this translation is probably the earliest known introduction of Indian numerals to the West. This manuscript begins with the words, Dixit Algoritmi: laudes deo rectori nostro atque defensori dicamus dignas (‘Algoritmi has spoken; praise be to God, our Lord and our Defender’, the Arab name Al-Khowarizmi having been transliterated into Algoritmi in Latin). In later years, careless readers of the book started attributing the calculational procedures described in the book to Algoritmi; that is how we got the term ‘algorithm’ for any computational procedure.
WHEN

Western Introduction to Indian numerals

Abul-Wafa

900 AD

Hindu works translated into Arabic

Brahmagupta

820 AD

Aryabhata

500 AD

Licoparnius: Arithmetica (530)

The Almagest by Ptolemy (150)

100 AD

William of Normandy conquers England (1066)

Firdausi: Shah-nama

680 AD

Martial Steps Islamic Invasion in Europe (732)

Hegira (622)

Pythagoras escapes

Fall of Rome (476)

Division of Roman Empire

Marcus Aurelius regime

WHERE

Figure 1.

Figure 2.
The use of Indian numerals was picked up by many scholars and was taught in major cities. In particular, the use of zero became well established in these discussions. Al-Khowarizmi himself says explicitly: ‘When nothing remains...put down a small circle so that the place be not empty... and the number of places is not diminished and one number is mistaken for the other.’ However, the new system was not accepted by the average man easily; ultimately, what tilted the balance in its favour were not scholarly expositions but commercial considerations! For by the end of the first millennium, Italy had grown to be a major mercantile power around the Mediterranean. Italian ships were used for crusades, Italian bankers lent the money, and Venice, Genoa and Pisa rose as cities of prominence. The traders and merchants very quickly realised the advantages of the Indo–Arabic number system. Blessed by big business, the system stayed. For example, the Margarita Philosophica (the philosophic pearl), a beautifully illustrated encyclopaedia which was widely used as a university textbook in the early sixteenth century, authored by the monk Gregor Reisch (c.1467–1525) discusses arithmetic using Indo–Arabic numerals compared to the use of a counting board (Figures 3 and 4).

Al-Khowarizimi also wrote another influential work called Al-jabr-wa’l Muquabala, (which could be translated as ‘The science
of transposition and cancellation’). Here, he gives a detailed exposition of the fundamentals of the subject, which has come to be called ‘alegbra’. Al-Khowarizmi discusses in a systematic manner – among other things – the solution of algebraic equations up to the quadratic order. The clarity of discussion in this book has made later workers call Al-Khowarizmi the ‘father of algebra’.

The synthesising power of Arabic civilisation also influenced trigonometry. This subject, well developed in both India and Greece due to the stimulus given by astronomical observations, attained a unified look in the hands of the Arabs. In Greece, it was developed by Aristarchus (310–230 BC), Hipparchus (around 140 BC) and most notably by Cladius Ptolemy (AD 85–165). In particular, Ptolemy constructed what he called a “table of chords” which is equivalent to the modern trigonometric table for the sine of an angle. He did this by using a very elegant geometrical procedure for all angles at half-degree intervals. This work, of course, was developed further by the Arabs. Abul-Wefa (AD 940–998), for example, produced the tables for sines and tangents at quarter-degree intervals; this table was used extensively by later scholars. Similar tables were constructed in the East by Aryabhata.

Incidentally, there is an interesting story behind the term ‘sine’. In trigonometry, one associates with each angle certain ratios usually called sine, tangent and secant (three other ratios, cosine, cotangent and cosecant, arise as complements of these three ratios). Of these three, the terms ‘tangent’ and ‘secant’ have clear geometrical meaning and correspond to the standard definition in Euclidean geometry (see Figure 5). How did the word ‘sine’ originate? Surprisingly enough, it came from the Sanskrit term jya-ardha (‘half of chord’)! This is how it happened.

The Indian mathematician, Aryabhata (AD 475–550), used the term jya-ardha to denote what we now call sine. This term, abbreviated as jya, was converted phonetically as jiba by the Arabs. Following the standard Arabic practice of dropping the
Box 1. Algebraic Symbolism

The earliest discussions in algebra, both in the East and the West, were rhetorical. Questions and answers were given in the form of dialogues or discussions and no symbols were used. The first two mathematicians to realise the powers of symbolic manipulations were Diophantus in Greece (AD 250?) and Brahmagupta (AD 700?) in India.

Diophantus had symbols to denote unknown quantities, various powers of an unknown quantity, reciprocals and equality. He also used Greek letters to denote numerals. The system followed by Brahmagupta was more elaborate. Addition was indicated by just placing the terms next to each other, subtraction by placing a dot over the term to be deducted, multiplication by writing bha (the first letter of bhavitha, the product), and square root by the prefix ka (from the word karana). The first unknown in the problem is denoted by ya and additional unknowns were indicated by the initial syllables of various colours.

The various mathematical symbols we use today came into existence over the centuries. The ‘equal’ sign (=) was due to Robert Recorde (Figure A). The ‘plus’ and ‘minus’ signs first appeared in print in an arithmetic text by John Widman published in 1489. The signs for multiplication and proportion were due to William Oughtred (1574–1660). It was Descartés who introduced the present compact notation with indices $a, a^2, a^3$, etc. Finally, $\pi$ as a ratio between the circumference and the diameter of a circle was first used by the English writer, William Jones, in 1706.

Figure A. A page from Robert Recorde’s The Whetstone of Witte (1557), showing the much longer equality sign.

Courtesy: http://www-groups.dcs.st-and.ac.uk/~history/Bookpages/Recorde4.jpeg
vowels in the written version, this became just \(jb\). Of course, the term \(jiba\) has no meaning in Arabic except in this technical context. Later writers, coming across \(jb\) as a shortened version for \(jiba\) (which appeared meaningless to them), decided to ‘correct’ it to \(jaib\) which is an Arabic word meaning ‘cove’ or ‘bay’. Still later, Gherardo of Cremona, while translating technical terms from Arabic to Latin, literally translated \(jaib\) to the Latin equivalent \(sinus\). This, in English, became ‘sine’. That is how a cavity in our upper nose and a trigonometric ratio ended up having the same roots.

**Suggested Reading**

